Cities are non-linear systems quite difficult to manage and even more so to design. They are complex open systems involving unpredictable behaviour generated by local and global agents. Suggestions found in expert literature for dealing with this complexity point towards developing design tools and methods structured under the concept of flexibility. They demand a design practice for dealing with change. Flexibility is the ability of a system of adapting or responding to changes in the environment. Ascher (2001) proposes as a strategy for new urbanism the development of an urbanism of devices for negotiating and elaborating solutions instead of designing fixed layouts.

This article will show the main concepts underlying the development of urban design tools and methods to address the production of flexible urban designs. The term ‘flexible urban design’ is defined as: a set of urban design solutions for a specific urban design problem formulation expressed through a set of interrelated design rules instead of the traditional fixed plan. The main concept is designing systems of solutions rather than a single solution.

The research shown in this article is part of a larger research project called City Induction and refers to the development of the generation module of an urban design tool for formulating, generating and evaluating urban designs (Duarte et al., forthcoming).

Urban design is practiced with an extensive support of analytical tools which allows us to capture some of the properties of the urban context. There are many kinds of analytical tools for such purpose (Gil and Duarte, 2008) (Stolk and Brömmelstroet, 2009). The most common examples are based on geographic information systems (gis) which allow for several kinds of spatial data analysis involving different types of data: morphological, social and economical.

The analysis of topological characteristics of the urban space can be enhanced with space syntax techniques (Hillier, 1996) or route structure analysis (Marshall, 2005). These analytical procedures improve the designers’ awareness on the characteristics of existing urban spaces or proposed design solutions. These methods can be applied to the design context before designing or to a solution integrated in the context for evaluating of the design solution. In the beginning of the design process they enhance the designer’s awareness on the existing
contextual conditions and at the end of the design process they allow to measure some properties of the urban environment already updated with the proposed solutions. The tangible meaning of the measurements obtained from these methods is a subject for expert interpretation but constructs a clearly improved awareness on the characteristics of the urban environment before and after designing.

It is common practice to confront a design proposal with other types of information related to it. The book ‘Spacematrix’ (Berghauser-Pont and Haupt, 2010) dedicates its first half to understanding the role of density measures in urban design and planning and the second half on understanding the tangible meaning of density measures and derived properties in regard to morphologic characteristics of urban fabrics.

In this research a model for developing a generative urban design tool was developed using as generative formalisms compound forms of shape and description grammars. Shape grammars (Stiny and Gips, 1972) are rule based formalisms to compute designs. Rules start from an initial shape applying shape transformations step by step to generate designs. Description rules apply to other characteristics of designs such as function, material or other aspects which semantically enhance the description of designs (Stiny, 1981).

In the proposed design system designs are obtained by arranging typical urban design moves called urban induction patterns (UIPs). UIPs are organized in a common structure following a design pattern structure (Gamma et al., 1995). The UIPs contain generative algorithms based on compound forms of shape and descriptions grammars which replicate design moves that urban designers recurrently use in their practice. For instance, they can draw main streets, a promenade, an orthogonal grid or a radial grid (Beirão et al., 2011). A complete design is obtained when a complete arrangement of design moves addressing all the requirements of the urban programme is selected. Informal applications of these concepts for urban design education can be found in (Beirão and Duarte, 2009).
“These analytical procedures improve the designers’ awareness on the characteristics of existing urban spaces or proposed design solutions.”

2 models – rule based versus parametric

Using the developed theoretical model, during the research two types of prototype tools were developed based on distinct design platforms.

**Model A** – developed in AutoCADCivil3D using the VBA programming interface (Beirão et al., 2010). In this model a set of new commands for AutoCAD were created and arranged in thematic toolbars: data inputs / composition axis (main streets) / grids / transformations / urban units / public spaces / function / building height / others. Each command corresponds to an urban design move which an urban designer can easily recognize by name. The commands follow the formal definition of UIPs adapted to the VBA programming language and they generate representations of design moves adapted to the design context. The representations are output in formats that can easily be inserted in the AutoCADMap platform. Point, line and polygon representations are stored in separate thematic layers. Simultaneously, the rules store information related to the design in a database which can also be accessed in the GIS platform. For instance, geometrical descriptions of streets are stored along with a hierarchic classification and attributes obeying a pre-defined ontology structure (Beirão et al., 2009) (Montenegro, 2010). Therefore the model is capable of producing design solutions and related quantitative and qualitative data. (figure 1)

**Model B** - developed in Rhinoceros using the Grasshopper programming interface (Beirão et al., 2011). This model produces parametric urban designs for a district area. The model works with a set of geometrical inputs divided in 4 types: site (defined by polygons); composition elements which are subdivided into main streets (defined by lines and curves) and focal points representing the location of the neighbourhood centre, local squares, public buildings and city objects in general; a vertical parameter defines the maximum number of floors; and a set of grid types (rectangular, radial and recursive). Each of these geometrical inputs has a set of associated parameter inputs. For instance, a main street has an attributed street width. The elements can be replaced or moved at any time during design exploration and the geometrical model is immediately updated. At each update the system calculates density measurements and derived properties following ‘Spacematrix’ density indicators. This capacity of the model allows the designer to grasp in a very interactive way the relations between the proposed morphological approaches and density properties with very straightforward visual interfaces. (figure 2)

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References


Gamma, E. et al., 1995. Design patterns: elements of reusable object-oriented software, Addison-wesley Reading, MA.


